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Local ecological knowledge reveals effects of policy-driven land use and cover change on beekeepers in Costa Rica

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ABSTRACT

Land use and cover (LUC) change is a major driver of ecosystem service loss worldwide. In response, policymakers have designed conservation strategies that incentivize the establishment and maintenance of LUC types associated with higher ecosystem service provision. Many of these policies also aim to promote social and economic goals such as reducing poverty. Attempts to measure the impact of policy-driven LUC change on stakeholders typically focus only on economic outcomes for landowning participants or aggregate the socioeconomic outcomes of diverse groups. In this study, we applied local ecological knowledge (LEK) held by beekeepers in Costa Rica to understand the impact of policy-driven LUC change on this specific group of often non-landowning stakeholders. Beekeeping is a globally important rural livelihood and provides pollination services to crops and wild plants. We synthesized beekeeper LEK using a mixed-methods approach including apiary mapping exercises (n = 215 apiaries), questionnaires (n = 50 participants), and follow-up interviews (n = 21 participants). Our study revealed that some policy-driven LUC changes have limited beekeepers' access to preferred land uses, such as secondary and mature forests with native trees. Participants reported concern for their livelihoods due to policy-driven spatial and temporal change of floral resources via the establishment of tree plantations, changes in pasture management, and laws that prohibit beekeeping in national parks and reserves. Our study provides evidence of unintended outcomes from land use policies, including Payment for Ecosystem Services, with disproportionate negative impacts on non-landowning residents who depend on natural resources in the landscape for their livelihoods. Our study illustrates potential inequality rising from current incentive mechanisms associated with Payments for Ecosystem Services and other conservation policies and calls for policymakers to consider LUC change impacts on non-landowning stakeholders.

1. Introduction

1.1. Ecosystem service loss and the rise of new policy mechanisms

Since the publication of the Millennium Ecosystem Assessment, scientists and policymakers have been increasingly focused on how changes in the environment impact the benefits humans derive from nature, collectively known as ecosystem services (Fisher et al., 2009). Many ecosystem services critical for human wellbeing are being degraded or used unsustainably worldwide, largely because of anthropogenic activities such as land use and cover (LUC) change (MEA, 2005). In response to ecosystem service loss, national and international policymakers have designed conservation strategies that incentivize "favorable" LUC types (Milder et al., 2010). These policies, such as Payments for Ecosystem Services (PES), are designed to reward those who maintain ecosystem service provision (e.g., landowners who reforest) via payments from the service beneficiaries (e.g., taxpayers or companies that seek carbon offsets). Because the policies create an economic incentive for conservation, they are described as win–win solutions to support human livelihoods while protecting ecosystem

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services (Muradian et al., 2013).

Despite the growing popularity of such policies, it is difficult to measure their impact on stakeholders. For example, policy-driven LUC change can result in ecosystem service trade-offs (where one service is increased at the expense of another; Jackson et al., 2005; Daw et al., 2015), spatial and temporal mismatch of service production and reception (Brauman et al., 2007; Fremier et al., 2013), and unequal benefits among stakeholders (Daw et al., 2011; Muradian et al., 2013; Paudyal et al., 2016). The most well developed approaches for measuring conservation incentives are based in economics (Martín-López et al., 2014), but some economic methods have been criticized for providing biased estimates of ecosystem service value and not being consistent with economic theory (Hausman 2012; Kling et al., 2012). Furthermore, studies on the social outcomes of PES often focus only on landowners or calculate the overall impact on communities by aggregating across different stakeholder groups (Daw et al., 2011). This may obscure differential or adverse impacts.

While many studies assert that conservation incentives are environmentally effective, increasing LUC types such as forest and their associated ecosystem services, there is evidence that such policies may benefit landowners without positively impacting non-landowning stakeholders (Calvet-Mir et al., 2015; Chomba et al., 2016; Kronenburg and Hubacek 2016). Small shifts in income, as well as shifts in ecosystem service provision, could have the most impact on non-landowning stakeholders because they are already vulnerable (Milder et al., 2010). Therefore, to improve ecosystem services-related strategies, policy assessments must incorporate non-landowning stakeholder perspectives (Plieninger et al., 2013; Gómez-Baggethun et al., 2014; Martín-López et al., 2014).

In this study, we used an interdisciplinary approach and a combination of data collection methods (mapping, questionnaire, and interview) and analytical tools (GIS analysis and quantitative and qualitative assessment of local ecological knowledge) to understand non-landowner perspectives on ecosystem service outcomes from policy-driven LUC change. We focused specifically on local ecological knowledge (LEK) from beekeepers, a group of stakeholders engaged in a rural livelihood practice that does not require land ownership. Specifically, we asked: how do beekeepers in the Nicoya Peninsula of Costa Rica perceive the quality of current LUC types for beekeeping, and how have changes in ecosystem service provision due to policy-driven LUC change impacted their livelihood? Our objectives were to: 1) describe LUC preferences among beekeepers; 2) map the current LUC types used by beekeepers; and 3) depict beekeeper perceptions of policy-driven LUC change and its impact on their livelihood.

1.2. Local ecological knowledge held by beekeepers

One way to better reflect local value systems and priorities when designing, evaluating, and improving conservation policy is to incorporate LEK (MEA, 2005; Turnhout et al., 2012; Gómez-Baggethun et al., 2013; Barber and Jackson 2015). LEK is defined as knowledge held by a specific group of people about their local ecosystem (Barber and Jackson 2015). LEK is developed from site-specific, contextualized observations and experiments generated by local users over the last few generations (Gadgil et al., 2003). Examples of successful application of LEK to policy include long-term wildlife population monitoring and management (Moller et al., 2004), technical interventions for livestock (Thapa et al., 1995), and improved agroforestry systems (e.g., Albertin and Nair 2004; Dahlquist et al., 2007; Polidoro et al., 2008; Anglaaere et al., 2011; Cerdán et al., 2012).

Beekeeping for honey production is a common rural livelihood strategy in many countries (Bradbear 2009) and beekeepers often develop LEK through their work. Beekeeping occupies a unique niche because it does not require landownership, provides pollination services for agriculture and biodiversity maintenance, and relies on other ecosystem services in the form of pollen and nectar resources from flowering plants. Beekeepers often take advantage of existing floral resources without requiring deforestation or competing with other livelihood strategies or conservation efforts in the landscape (Brown, 2001; Brown and Paxton, 2009; Ingram and Njikeu 2011). As a result, beekeepers have extensive knowledge of the quantity, quality, and location of floral resources for honeybees based on the production of their colonies and location of successful hives. The potential of using this type of LEK to understand and interpret observations of LUC change has been historically underappreciated and largely untapped (Kleinman and Suryanarayanan, 2012).

In 2016, the United Nations Intergovernmental Panel on Biodiversity and Ecosystem Services emphasized the importance of integrating indigenous and local knowledge into solutions to a specific ecosystem service challenge: the threat of pollinator loss (IPBES, 2016). Animal-mediated pollination is critical for crop production (Klein et al., 2007) and wild plant reproduction (Ollerton et al., 2011). Bees are the primary animal pollinators in most regions of the world (Klein et al., 2007; Winfree et al., 2008) and contribute to the pollination of both native plants and crops (Garibaldi et al., 2013). Several studies have recently raised concerns about bee population declines worldwide (Potts et al., 2010; Burkle et al., 2013; Goulson et al., 2015) and specifically in the tropics (Frankie et al., 1997), but there is a dearth of research related to pollinators (Archer et al., 2014) and beekeeping activities in the tropics.

The majority of managed pollination services to agriculture are provided by the European honeybee (*Apis mellifera;* Potts et al., 2010). The production of honeybee-dependent crops has outpaced the increase in managed beehives worldwide (Aizen and Harder, 2009). This trend is driven by several factors, including the loss of floral resources to support large populations of managed bees during seasons when crops are not in bloom (Aizen and Harder, 2009). The extent to which anthropogenic LUC change influences bee populations and the rural livelihoods that depend on managed pollinators such as the honeybee is largely unknown (Vanbergen 2013). Understanding the influence of LUC change on managed bees has the potential to improve rural livelihoods and help to ensure the future of globally important pollination services.

1.3. Study region and land use policy context

The Nicoya Peninsula (Fig. 1), bordered by the Pacific Ocean to the west and the Gulf of Nicoya to the east, is a mix of seasonally dry and moist tropical ecological life zones (Calvo-Alvarado et al., 2009). Currently the peninsula is dominated by secondary forest, pasture, and tree plantations (Serrano Dávila, 2005), but in the past 75 years, the region has undergone dramatic changes in land cover. Due to high beef prices and a growing cattle industry, extensive dry tropical forest in the peninsula was converted to pasture from the 1950s to mid-1970s (McLennan and Garvin 2012). A drop in the international beef market combined with a severe El Niño-induced drought in the late 1970s resulted in land abandonment and migration from the region. Over subsequent years, supported by land stewardship led by local institutions and national policy reforms that focused on forest protection, much of the pastureland has regenerated into secondary forest (Vallejo et al., 2006). In Hojancha County, for example, forest cover increased from 14% to 52% between 1970 and 2005 (Serrano Dávila, 2005).

Numerous national policies have contributed to LUC trends in the Nicoya Peninsula (Table 1). Regulation of timber harvest, forestry incentives, and a national PES scheme were created to incentivize reforestation and forest conservation on private lands. These policies have had highly contested impacts on both LUC change and socio-economic factors (Table 1). While most of the strategies focused on supporting native forest types, some PES-sponsored reforestation has occurred in the form of monoculture plantations of introduced species like teak (*Tectona grandis*) and melina (*Gmelina arborea*). The effects of policy-driven reforestation trends are evident in the Nicoya Peninsula, where